AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE Atlanta, GA 30329 404-636-8400

TC/TG/TRG MINUTES COVER SHEET

(Minutes of all meetings are to be distributed to all persons listed below within 60 days following the meeting.)

TC/TG/TRG NO. TC 7.5 **DATE: February 8, 2005**

TC/TG/TRG TITLE: Smart Building Systems

DATE OF MEETING: February 6, 2005 **LOCATION: Orlando, FL**

Members Present	Appt	Members Absent	Appt	Ex-Officio Members and Additional Attendance
John House, Chair (V)	03-05	Osman Ahmed (V)	02-06	Peter Armstrong
Steve Blanc, (V)	04-08	Jonathan Wright (V)	03-07	Piotr Domanski
Michael Brandemuehl (V)	03-07			Mohsen Farzad
James Braun (V)	03-07			Gregor Henze
Arthur Dexter, Int't Member	01-05	**Corresponding Members**		Curtis Klaassen
Cliff Federspiel (V)	02-06	Narendra Amarani, CM	04-	Vance Payne
James W. Gartner (V)	03-07	Dave Branson, CM	01-	David Shipley
Rich Hackner, Program Subc. (V)	01-05	Marty Burns, CM	02-	Vernon Smith
Phil Haves (V)	01-05	Jim Butler, CM	02-	Gene Strehlow
Bill Healy (V)	04-08	Maria Corsi, CM	03-	
Srinivas Katipamula; Tech. Dev. Subc. Chair (V)	01-05	Charles Culp, CM	00-	
Agami Reddy (V)	02-06	Mark Johnson, CM	04-	
		Michael Kintner-Meyer, CM	03-	
Corresponding Members		Mingsheng Liu, CM	03-	
David Bornside	04-	Carol Lomonaco, CM	00-	
Mike Brambley, Vice Chair, Research Subc Chair, CM	03-	John Mitchell , CM	00-	
Barry Bridges, CM	02-	Ron Nelson, CM	98-	
Natascha Castro, Testing & Evaluation Subc, Web Master, CM	04-	Leslie Norford, Handbook Subc, CM		
Carlos Haiad, CM	04-	Hung Mahn Pham, CM	01-	
David Kahn, CM	96-	Kinga Porst, CM	02-	
George Kelly, CM	01-	Mike Pouchak, CM	03-	
Darrell Massie, CM	03-	Andrew Price, CM	03-	
Robert Old, CM	00-	Barry Reardon, CM	99-	
Glenn Remington, CM	02-	Todd Rossi, Secretary, CM	03-	
Keith Temple, CM	03-	John Seem, CM	03-	
Peng Xu, Comm. & Int. Subc. Chair, CM	02-	Pornsak Songkakul, CM	02-	
		James Winston, CM	96-	
		Chariti Young, CM	02-	
		Xiaohui Zhou, CM	03-	

(V) = voting member

DISTRIBUTION:
ALL MEMBERS AND CORRESPONDING MEMBERS OF TC/TG/TRG,
TAC CHAIR: William Bahnfleth
TAC SECTION HEAD: Janice Peterson
ALL COMMITTEE LIAISONS AS SHOWN ON TC/TG/TRG ROSTERS:

Program: Frank Schambach	Standards: Richard Hermans
Research: Patrick Hughes	Special Publications: Kimball Ferguson
CTT: Kenneth Rhoden	Staff Liaison (Stds): Claire Ramspeck
Prof. Dev.: Mark Hydeman	Staff Liaison (Resch/Tech Srvc): Michael Vaughn

"These draft minutes have not been approved and are not the official, approved record until approved by this (council/committee)."

ASHRAE TC Activities Sheet

DATE: February 8, 2005
TC NO. TC 7.5 TC TITLE: Smart Building Systems
CHAIR: John House VICE CHAIR: Mike Brambley

TC Meeting Schedule

Location, past 12 mo.	Date	Location, next 12 mo.	Date
Nashville	6/29/04	Denver	6/28/05
Orlando	2/8/05	Chicago	1/21/06

TC Subcommittees

Subcommittee	Chair
Technology Development	S. Katipamula
Communications and Integration	P. Xu
Testing & Evaluation	N. Castro
Research	M. Brambley
Program	R. Hackner
Handbook	L. Norford

Program List for 2005 Denver Meeting:

"What is needed to achieve widespread market acceptance of HVAC Fault Detection and Diagnostic Systems?"	W. Goetzler	Accepted
"In 2010: What will a building have to say?… and who will listen?"	P. Haves	Not accepted
"What the utility wants to do to your building and how you will benefit"	M. Kintner-Meyer	Not accepted

Past Research Projects (last 3 years)

1139-RP Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment

Current Research Projects

Technology Development Subcommittee
1275-RP "Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II" (Phil Haves – PMSC Chair)

Testing and Evaluation
1274-RP "Field Performance Assessment of Package Equipment to Quantify the Benefits of Proper Service" (Todd Rossi – PMSC Chair)

1312-TRP "Tools for Evaluating FDD Methods for Air Handling Units" - **Conditionally Approved**

2004 – 2005 Research Plan (approved June 29, 2004)

Priority	Project	Contribution	Status
1	Fault Detection and Diagnostics for Centrifugal Chillers – Phase 3: Real-Time Implementation	Srinivas Katipamula, John House, Todd Rossi, Jim Braun, Natascha Castro	Prioritized. RAC recommended waiting to submit workstatement until Phase 2 is completed. Will work on scope of work for Orlando.
2	Design and Demonstration of a Self-Configuration Concept for an HVAC Control System	Michael Kintner-Meyer	Draft discussed in Anaheim and suggestions made for substantial revision. No progress for Nashville.
3	FDD for Supermarket Refrigeration	Daniel Choiniere	Draft RTAR presented at the Anaheim meeting, no change at the Nashville meeting. Updated RTAR will be emailed to members in December before the Orlando meeting.
4	Added-Value of Wireless Temperature Sensor Network in a Building	Jin Wen and Agami Reddy	New draft RTAR prepared for Nashville meeting. RTAR will be updated to address comments and feedback from members. Updated RTAR will be emailed to members in December for review before the Orlando meeting.
5	Universal Chiller Model for FDD Training and Testing	Agami Reddy	New idea, no RTAR. Agami will draft an RTAR and email it to members in December before the Orlando meeting.
6	Whole-Building FDD	Les Norford	Idea proposed in Honolulu. No RTAR has been drafted yet, but Les volunteered to work on it and provide a draft by December 2004.
7	Smart Sensor Systems for Reducing Bias Errors in the Measurement of Air Temperatures and Flows in Air-Handling Units	Arthur Dexter and Phil Haves	One-page description written. No progress to report at the Nashville meeting.
8	Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostics Systems	Mike Brambley and Todd Rossi	Draft RTAR written. On hold. No progress to report.

Co-sponsored RTARs

	Real-Time Optimal Control in a Distributed Environment	Jim Braun, George Kelly, Maria Corsi	RTAR submitted by TC 7.4, TC 7.5 is co-sponsor. RTAR has been approved. Jonathan Wright will draft a WS for the Orlando Meeting.

Other Non-Prioritized Topics Proposed

- Prototyping and Field Testing of Utility-Consumer Information Services – Michael Kintner-Meyer and Marty Burns
- Integrating data in computer-based maintenance management systems with energy management and control systems.

Technical Papers from Sponsored Research

RP-1011

Final report for ASHRAE Research Project RP-1011, "Utility/Energy Management and Control Systems (EMCS) Communication Protocol Requirements" is available on the TC 7.5 web site.

RP-1020

Norford, L. K., J. A. Wright, R. Buswell, and D. Luo. 2000. "Demonstration of Fault Detection and Diagnosis Methods in a Real Building (ASHRAE 1020-RP)." ASHRAE 1020-RP Final Report.

Luo, D., L. K. Norford, S. R. Shaw, and S. B. Leeb. 2002. "Monitoring HVAC Equipment Electrical Loads from a Centralized Location - Methods and Field Test Results." ASHRAE Transactions Vol. 108(1).

Shaw, S. R., L. K. Norford, D. Luo, and S. B. Leeb. 2002. "Detection of HVAC Faults via Electrical LoadMonitoring." International Journal of HVAC&R Research, 8(1):13-40.

Norford, L.K., J. A. Wright, R. A. Buswell, D. Luo, C. Klaassen, and A. Suby. 2002. "Demonstration of Fault Detection and Diagnosis Methods for Air-Handling Units (ASHRAE 1020-RP)." International Journal of HVAC&R Research, 8(1):41-72.

RP-1043

Bendapudi, S., Braun, J.E., and Groll, E.A., "A Dynamic Model of a Centrifugal Chiller System – Model Development, Numerical Study and Validation," ASHRAE transactions, Vol. 111, Pt. 1, 18 pages, 2005.

Final report for ASHRAE Research Project RP-1043, " Fault Detection and Diagnostic

Requirements and Evaluation Tools for Chillers" is available on the TC 7.5 web site.

Technical paper from 1043-RP, Comstock, M.C., Braun, J.E., and Groll, E.A., "The Sensitivity of Chiller Performance to Common Faults," International Journal of HVAC&R Research, Vol. 7, No. 3, pp. 263-279, 2001.

Technical paper from 1043-RP, Comstock, M.C., Braun, J.E., and Groll, E.A., "A Survey of Common Faults for Chillers," ASHRAE Transactions, Vol. 108, Pt. 1, 2002.

RP-1139

Andersen, K.K., and Reddy, T.A., 2002. "The Error in Variable (EIV) Regression Approach as a Means of Identifying Unbiased Physical Parameter Estimates: Application to Chiller Performance Data", International Journal of HVAC&R Research, vol.8, no.3, pp. 295-309, July.

Reddy, T.A. and Andersen, K.K., 2002. "An Evaluation of Classical Steady-state Off-line Linear Parameter Estimation Methods Applied to Chiller Performance Data", International Journal of HVAC&R Research, vol.8, no.1, pp.101-124.

Reddy, T.A., Niebur, D., Andersen, K.K., Pericolo, P.P. and Cabrera, G., 2003. "Evaluation of the Suitability of Different Chiller Performance Models for Online Training Applied to Automated Fault Detection and Diagnosis", International Journal of HVAC&R Research, Vol.9, No.4, pp. 365-384, October.

Reddy, T.A., Andersen, K.K. and Niebur, D., 2003. "Information Content of Incoming Data During Field Monitoring: Application to Online Chiller Modeling", International Journal of HVAC&R Research, Vol.9, no.4, pp.385-414, October.

TC Sponsored Symposia (past 3 years, present, planned)

HVAC Diagnostics: Development to Implementation Part 1 (House)	Atlantic City, 1/02
HVAC Diagnostics: Development to Implementation Part 2 (Dexter)	Atlantic City, 1/02
FDD, Operation and Maintenance of HVAC Systems (Kelly, TC 1.4 co-sponsor)	Kansas City, 6/03
Automated Functional Testing: Methodologies and Air-Handling Unit Applications (House)	Orlando, 1/05

TC Sponsored Seminars (past 3 years, present, planned)

Title	**Date** (Given or Planned)
Intelligent Agents - What They Can Do For You (Ahmed, TC 4.6 co-sponsor)	Honolulu, 6/02
Self-Configuring Control Systems: Technology and Potential Benefits (Brambley, TC 4.6 co-sponsor)	Honolulu, 6/02
Experience with Demand Responsiveness Programs (Haves, TC 4.6 co-sponsor)	Honolulu, 6/02
New Issues in State of the Art DDC Systems (Atkinson, TC 1.4 co-sponsor)	Honolulu, 6/02

Automated Functional Testing of HVAC Systems (Haves, TC 1.4 and 4.6 co-sponsors)	Chicago, 1/03
New Issues with State-of-the-Art DDC (Atkinson, TC 1.4 and 1.5 co-sponsors)	Chicago, 1/03
Wireless Sensors for Building Applications (Healy, TC 1.4 co-sponsor)	Kansas City, 6/03
Improved Operations for California Buildings -Part 1 (Haiad, TC 7.4 lead)	Anaheim, 1/04
Improved Operations for California Buildings -Part 2 (Scruton, co-sponsored with TC 7.4)	Anaheim, 1/04
Automated Commissioning Tools (Maria Corsi, co-sponsored with TC 7.3)	Anaheim, 1/04
State of the Art Issues for DDC Systems (Atkinson, TC 1.4 lead)	Anaheim, 1/04
Models for Automated Building/HVAC Fault Detection and Diagnostics (Brambley, co-sponsored with TC 4.7)	Nashville, 6/04
Demand Response and Building Control (Xu, TC 7.4 lead)	Nashville, 6/04
Control Challenges and Opportunities with Emerging DDC Technologies (Bridges, TC 1.4 lead)	Orlando, 1/05
Future Intelligent Control Systems: They are Here Today (Braun, TC 7.4 lead)	Orlando, 1/05

TC Sponsored Forums (past 3 years, present, planned)

Title	**Date** (Given or Planned)
What Should ASHRAE's Role be in IFC and XML Standards (Gowri, GPC20 and TC 1.5 cosponsor)	Chicago, 1/03
Achieving Market Acceptance of HVAC Fault Detection and Diagnostic Systems (Goetzler, co-sponsored with TC 7.4)	Orlando, 1/05

TC Sponsored Public Sessions (past 3 years, present, planned): None
Journal Publications (past 3 years, present, planned): None

ASHRAE TC 7.5, Smart Building Systems

February 8, 2005 – Orlando, FL

Call to Order, Roll Call, Introductions

The meeting was called to order at 3:40 PM with Chairman John House presiding. Roll call was taken with 12 of 14 voting members in attendance. House distributed the Agenda (the call-to-meeting letter and the agenda are in Appendix A).

Voting members present: Steve Blanc, James Braun, Arthur Dexter, Cliff Federspiel, James Gartner, Rich Hackner, Carlos Haiad, Phil Haves, Bill Healy, Srinivas Katipamula, Agami Reddy, John House

Committee Scope

The Chair read the committee scope for the benefit of all in attendance. (see Appendix B)

Approval of Minutes

House asked for comments and changes to the Nashville minutes. Mike Brambley provided an editorial change.

Motion: Move to approve minutes subject to editorial changes (Motion: Rich Hackner, Second: Phil Haves). **Vote:** 10/0/0 chair not voting (one voting member had left the room temporarily).

Chair's Announcements (John House):

John House attended the TC Chair's Breakfast Meeting for Section 7 on Sunday morning. Announcements stemming from the meeting follow:

1. ASHRAE is encouraging TCs to send out meeting minutes in a timely manner. Minutes for this meeting should be distributed by April 30, 2005.
   (House asked subcommittee chairs to submit summaries of their reports to the secretary by the end of February.)

2. ASHRAE is also encouraging TCs to have a web site up and running and linked to ASHRAE's web site. The web sites of TCs 1.6, 2.6 and 7.9 have been cited as examples of good web sites.

3. Webmaster training will be held in Denver. Contact Mike Vaughn to set up a one-on-one meeting for the training. Contact Mike Vaughn to set up the meeting.

4. Rosters should be sent electronically to Janice Peterson by Feb. 24, 2005 at the latest.

5. TCs are asked to coordinate programs and to make other TCs in Section 7 aware of topics that may be of general interest.

6. Each TC should assign a member to keep track of Frequently Asked Questions (FAQs) and make sure they are up to date. FAQs can be found on the ASHRAE web site. New questions will be sent to appropriate committees as they come in.

7. There is a list-serve service available to TCs. Contact Mike Vaughn for more information.

8. There were no nominations for the Hightower award for outstanding service to the TC. This is an award for service for a single year and not a lifetime service award. In response to the lack of nominations, it has been suggested that TCs form an "Honors and Awards" Subcommittee, which would make recommendations for awards such as the Hightower Award.

9. Program Committee is reminding TCs that the TCs are responsible for content of programs.

10. TC chairs and research chairs are encouraged to attend one of the four Research Advisory Panel workshops that will cover the draft ASHRAE Strategic Research Plan.

11. ASHRAE is co-sponsoring CLIMA 2005. The conference will take place in Lausanne, Switzerland Oct. 9-12, 2005.

Technology Development Subcommittee (Srinivas Katipamula)

Srinivas Katipamula reported on topics discussed at the subcommittee meeting.

A draft RTAR on the topic of fault detection and diagnosis for supermarkets was presented by Daniel Choiniere at Nashville. No changes have been made to the RTAR since then. There was a lengthy discussion of the RTAR at the subcommittee meeting. Hung Pham (Emerson-Copeland) provided numerous comments and indicated he might be able to provide a list of common faults in refrigeration systems and field data. Several others provided useful comments.

ACTION: House volunteered to take the lead on revisions. Anyone interested in contributing to the RTAR is encouraged to contact House or Katipamula.

The subcommittee also discussed the research topic "Added Value of Wireless Sensors" (what benefits do they bring to the building environment) that was presented as an RTAR at Nashville. The topic has evolved to exploring the benefits that can be achieved from sensor networks (wired or wireless) in a building environment.

ACTION: Bill Healy volunteered to take the lead on revisions for the next meeting.

Other research topics discussed at the subcommittee meeting include the following:

- FDD at the whole building level – Les Norford originally proposed this topic.

  ACTION: Peter Armstrong indicated he would discuss the topic with Les Norford and draft and RTAR prior to the next meeting.

- "Smart Sensor Systems to Reduce the Bias Errors of Measurements of Air Temperatures in Flows in AHUs" – A two page summary of the topic was written several years ago. Arthur Dexter and Phil Haves were two of the original champions. Dexter is no longer able to devote time to developing the RTAR.

ACTION: Phil Haves will attempt to get Charlie Culp involved in reviewing and revising the existing document.

- "Resolving Discrepancies Between Multiple Hierarchically Related FDD Systems" – A work statement was written several years ago on this topic by Mike Brambley and Todd Rossi. No progress has been made in the recent past. Brambley indicated he does not have the time or interest to work on the topic and proposed we remove it from our long range research plan the next time we prioritize that plan.
- "Real Time Optimal Control in a Distributed Environment" – This is an RTAR that we co-sponsored with TC 7.4. The RTAR has been accepted by RAC, but a workstatement has not been drafted.

RP-1275 Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II – Phil Haves (PMSC chair) provided the PMSC report for RP-1275. The aim of the project is to evaluate fault detection and diagnosis (FDD) methods for existing chillers in the field. Four diagnostic methods are being evaluated. The contractor is Drexel University, Agami Reddy PI, with Purdue University as a subcontractor. Due to contractual issues, the project did not officially begin until December, 2003. There was uncertainty at the PMSC meeting concerning the contract end date. If that date is prior to the next ASHRAE meeting, it will require an email vote by the committee for a no-cost extension to the project. Notes from the PMSC meeting are provided in Appendix H.

Communications and Integration Subcommittee – Peng Xu

The first topic discussed at the subcommittee meeting was a predictive "what if" simulation tool would allow building operators to understand what the effect of certain control changes would be in terms of energy demand and comfort. Steve Blanc developed a description of the tool. The tool is similar to other tools being proposed by TC 4.7 and TC 7.4 (flight simulator for buildings).

ACTION: Blanc will consult with TC 7.4 and 4.7 and revise the draft he prepared for the next meeting in Denver.

A second topic discussed was an RTAR written by Les Norford entitled "Short-term Load Control in a Building via HVAC Setpoint Adjustment". The RTAR was written for TC 7.4 and Norford is looking for co-sponsorship from TC 7.5. The RTAR was submitted to RAC last August by TC 7.4, but it was not accepted by RAC. There was considerable discussion of the topic and Norford will be revising the RTAR accordingly.

A third topic discussed by an idea presented by Carlos Haiad on different demand limiting strategies for different buildings. Haiad commented that Southern California Edison has a current project on this topic and suggested it would be appropriate to wait until that work is completed to identify future needs in this area.

The fourth topic discussed was the RTAR / workstatement "Self Configuring Control Systems". The RTAR was prioritized by RAC several years ago.
Michael Kintner-Meyer is the lead on this topic.

ACTION: Kintner-Meyer will collect comments on the workstatement from previous meetings

and revise for the next meeting.

TC 7.5 Testing and Evaluation Subcommittee Report – Natascha Castro

Subcommittee discussed two main items: 1) WS-1312 "Tools for Evaluating FDD Methods for AHUs" and 2) a current RTAR "Fault Detection and Diagnostics for Centrifugal Chillers- Phase 3: Real-Time Implementation."

1) John House is the Champion for WS-1312 which is co-sponsored by TC 1.4, TC 7.3, and TC 7.4. It is conditionally accepted by RAC – the first condition is to wait for Purdue to finish the dynamic cooling coil model (RP-1194), which is complete and reviewed by PMS on Monday. The work on RP-1194 Work is to be completed by June, with final report due in August. The second condition concerned the funding level and subsequent discussions resulted in the budget being increased from 120K to 140K.

There was concern that the dynamic cooling coil model was computationally intensive and only slightly faster than real time. However, the issue will likely be resolved in the coming months as Purdue focuses on model simplifications that will likely produce a significant increase in the computational speed.

Motion: Motion that TC 7.5 request TC 7.4 formalize acceptance of the preliminary chilled water cooling coil model description from RP-1194 and that the model be made available to potential bidders, and that TC 7.5 notify RAC that the WS-1312 is ready for bid. (Motion: Brandemuehl, Second: Haves). **Vote:** 10/0/0 chair not voting (Arthur Dexter had departed by the time this vote was taken)

2) The current RTAR for Chiller FDD Phase – III is prioritized. RAC suggested that we delay submitting the workstatement until RP-1275 (Phase II) is complete (12 months off). Srinivas Katipamula reported that Todd Rossi has a patent on FDD for vapor compression systems, which appears to cover phase III chiller work.

ACTION: House and Katipamula offered to follow up with Rossi and to consult ASHRAE concerning the appropriateness of ASHRAE pursuing this research in light of the existing patent.

The next item discussed was a workstatement by TC 7.9 on the Impact of Commissioning on Life Cycle Cost. The TC is planning a rewrite of the workstatement since this is somewhat dated but there may be some opportunity to give our input. Anyone interested in the topic can contact Natascha Castro.

1274-RP Field Performance Assessment of Package Equipment to Quantify the Benefits of Proper Service

Keith Temple (PMSC member) chaired the PMSC meeting in Todd Rossi's absence and provided the PMSC report for RP-1274. The contractor is ADM Associates. To date there has not been any field measurements made. A summary of key issues coming from the PMSC meeting are provided below:

1. Contractor had provided "Literature Review" (not dated) and "Field Diagnostic Test On-Site Procedure for Roof Top Unitary Equipment" (dated January 28, 2005) to Rossi prior to the meeting. Documents were distributed to the PMSC by e-mail.

2. The contractor provided their proposed timeline for field testing as follows: Los Angeles in May, Sacramento in June, and Baltimore in July and August.

3. The contractor was instructed to revise the field test procedure and resubmit for approval by the PMSC before any fieldwork is started. The contractor requested approval of the field test procedure by the end of February. Proposed schedule: comments to contractor in one week, revised test procedure from contractor in two weeks, final comments from PMSC in three weeks with approval to follow.

4. The committee identified two key items that need to be included in the field test procedure document: 1) the description of the test instruments including uncertainty and 2) the field test form (updated from version reviewed at Nashville meeting).

5. Additional comments from the committee on the field test procedure:

    a. Qualitative words, such as "significantly", need to be replaced with quantitative information.

    b. The following items need clarification: instrument calibration, airflow measurement procedure, airflow measurements will be made for all units and supplemented with other data.

Discussions at the main committee meeting emphasized the need to clarify the status of the testing plan to ensure that it has been approved by the PMSC prior to commencing field testing. There was also discussion of whether or not there is a Gantt chart for the project. Based on the fact that some testing was originally planned for the fall of 2004 and this testing did not occur, the project may be as much as 4-5 months behind schedule.

ACTION: Temple will instruct the contractor that before field testing begins, they need to have the document "Technical Approach and Workplan" (dated July 15, 2004) and the document "Field Diagnostic Tests: Onsite Procedures for Rooftop Unitary Equipment" (which includes the specifications for instrumentation and the field test template) revised and resubmitted for a approval by the PMSC. This should be accomplished in the next three weeks.

Research Subcommittee – Mike Brambley

Mike Brambley asked Srinivas Katipamula to provide announcements from the Research Chair's breakfast (Brambley was unable to attend).

Katipamula reported that one of the focuses of the meeting was the new rating system for RTARs. The criteria will be available on the ASHRAE web site.

Brambley distributed our current research plan. Brambley indicated he would work with the subcommittee chairs to update the plan to reflect the current status of each project.

Brambley attended a workshop Monday where he provided comments collected at the TC 7.5 Research Subcommittee Meeting on ASHRAE's "Strategic Research Plan", which has been developed by the Research Advisory Panel (RAP). Examples of the comments Brambley

provided to RAP on behalf of TC 7.5 include the following:

- It should be emphasized that the topics included in the strategic plan are examples and do not constitute an exhaustive list.
- There did not seem to be any goals for HVAC in the strategic plan, although there was an emphasis on refrigeration.

Additional comments can be provided to Brambley or directly to John Mitchell (rapchair@ashrae.net).

Brambley also reported on an effort he is undertaking to identify gaps in TC 7.5 research that the committee thinks should be filled (recognizing we need champions to spearhead new research topics). Brambley is also leading an effort to look at the three topical subcommittees (Technology Development; Communications and Integration; Testing and Evaluation) and determine if this is the best organization for the committee. At the subcommittee meeting, Phil Haves suggested we collapse all the subcommittees into a single committee and conduct the meeting based a process that might involve brainstorming at the beginning of the meeting, work on RTARs and workstatements in the middle part of the meeting, and program and other issues during the latter part of the meeting.

ACTION: Brambley will continue the dialogue to identify research gaps via email and report at the next meeting whether we have identified any gaps. Brambley will also continue the dialogue on the committee structure and provide a proposal at the next meeting for possible restructuring of the subcommittees, or endorsement of the current structure. Brambley will invite everyone on the distribution list to participate in this dialogue.

Program Subcommittee –Rich Hackner

Rich Hackner led a discussion of program topics for Denver. Hackner noted that the TC had one sponsored forum and one sponsored symposium at this meeting, as well as two co-sponsored seminars. Mike Brambley noted that a large number of programs were rejected for this meeting and the Program Committee is working on a recommendation for creating more program slots. There was concern expressed about the new 1-hour symposium format. This results in only 15 minutes to present a paper, which is not adequate in the opinion of many.

ACTION: Brambley invited anyone concerned about the new symposium format to send comments to him and he will forward them to the program committee. The next Program Committee meeting is early March.

Hackner provided a list of possible program topics. The seminar "In 2010: What will a building have to say? … and who will listen?" will be dropped. The program topics were prioritized as follows:

Priority 1: Forum *"What the Utility Wants to Do to Your Building and How You will Benefit"* (Chair: Michael Kintner-Meyer)

Priority 2 Seminar *"Economic Value of FDD - Who Benefits and by How Much?"* (Chair: Phil Haves)
Co-Sponsors: TC 7.4

Priority 3 Forum *"Wireless Sensing and Control …Where Is It Needed and What Should It*

Control?" (Chair: Michael Brambley)
Co-Sponsors: TC 1.4? and TC 7.4

MOTION: Move to approve the program plan as prioritized (Motion: Haves, Second: Healy).
Vote: 10/0/0 chair not voting.

Other program topics discussed included the following:

Symposium *"Automated Commissioning …From the Case Files of IEA Annex 40"* (Lead: John House)
Possible Co-sponsors: TC 7.9

Seminar *"FDD …Fault Detection and Diagnostics…but What about Correction?"* (Lead: Someone from PNNL)
Possible Co-Sponsors: TC 7.4

Seminar *"Peel and Stick …The Future in HVAC Sensing Technology?"* (Lead: Mike Brambley)
Possible Co-Sponsors: TC 1.4
Possible Speakers: Mike Schell and Glen Remington

Handbook Subcommittee Report – Les Norford

Les Norford (Handbook Chair) was unable to attend the meeting, but provided the following written report of the status of his effort to develop handbook material for TC 7.5.

The chair of the committee has begun to prepare a draft of material on fault detection and diagnosis. The goal is to offer it to TC 7.3, Operation and Maintenance Management, for inclusion in Chapter 38 of the ASHRAE Applications Handbook, which will be revised in print form in 2007.

TC 7.3 members were receptive to this idea when it was presented to them at the Nashville meeting. TC 7.3 members affirmed that support at the Orlando meeting of their handbook subcommittee. However, members expressed some concern that the material submitted by TC 7.5 could overwhelm their chapter. The TC 7.5 handbook subcommittee chair stated that the short-term goal was to introduce about two pages into the handbook; in the long term, more material could be presented, perhaps as a separate chapter or in combination with other material, as part of a re-thinking of the chapters under the purview of the new Section 7. TC 7.3 members noted that ASHRAE's HandbookCD+, updated annually, might be a medium for extending the material prior to the 2011 print version.

The material in preparation includes a motivation for FDD based on energy use and operating costs; a summary of reported equipment faults and repair costs, concentrating on chillers and unitary cooling equipment; financial benefits of FDD, based on pilot programs; a description of the key steps of FDD; a listing and brief description of FDD methods used for HVAC systems; and examples of implemented FDD systems. The material draws from papers and research reports prepared primarily by TC 7.5 members, who will be asked to provide electronic copies of figures and tables and to review draft text.

The schedule for the work is to circulate a draft before the Denver meeting, then seek approval of

TC 7.5 at Denver and present the material to TC 7.3 for its consideration. TC 7.3 will be kept informed of progress. TC 7.3 members will need to approve the material at their Chicago meeting, in January 2006.

House indicated he plans to provide additional time for the handbook discussions at the subcommittee meetings in Denver.

Web – Natascha Castro

Seminar presentations from the Anaheim and Nashville meetings were posted on the TC 7.5 website. Mike Brambley indicated his presentation and the presentation of Dick Kelso at the Nashville meeting were not on the ASHRAE CD.

Old Business

None

New Business

None

Adjourn

Motion: Move to adjourn (Motion: Hackner, Second: Haves). Motion approved by unanimous voice vote.

Appendices

A. Call to Meeting and Agenda
B. Scope and Organization
C. Technology Development Subcommittee Report
D. Communications and Integration Subcommittee Report
E. Testing and Evaluation Subcommittee Report
F. Research Subcommittee Meeting
G. Program Notes
H. 1275-RP PMSC Subcommittee Report
I. List of Subcommittee and Committee Attendees

Appendix A.
TC 7.5 Call to Meeting and Agenda

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

1791 Tullie Circle, NE, Atlanta, Georgia 30329-2305 404-636-8400 | Fax 404-321-5478

Reply to: John House
Energy Resource Station
DMACC, 2006 S. Ankeny Blvd.
Ankeny, IA 50021
jhouse@energy.iastate.edu

January 5, 2004

Dear TC 7.5 Member, International Member, or Corresponding Member:

The **TC** on Smart Building Systems will meet in the Wyndham Palace Resort in Orlando according to the following schedule:

TC 7.5	Tech. Development	Sunday (2/6)	3:00-3:40p	Wyndham/England
TC 7.5	Comm. & Integration	Sunday (2/6)	3:40-4:20p	Wyndham/England
TC 7.5	Testing & Evaluation	Sunday (2/6)	4:20-5:00p	Wyndham/England
TC 7.5	Research	Sunday (2/6)	5:00-5:45p	Wyndham/England
TC7.5	Handbook	Sunday (2/6)	5:45-6:00p	Wyndham/England
TC 7.5	PMS 1274-RP	Sunday (2/6)	6:00-7:30p	Wyndham/England
TC 7.5	PMS 1275-RP	Tuesday (2/8)	1:30-3:00p	Wyndham/Scotland C
TC 7.5	**Smart Building Systems**	**Tuesday (2/8)**	**3:30-6:00p**	Wyndham/Scotland A

TC 7.5 is sponsoring or co-sponsoring the following program sessions:

Forum 2: Achieving Market Acceptance of HVAC Fault Detection and Diagnostic Systems
(TC 7.5 sponsor; TC 7.4 co-sponsor)
Sunday, February 6, 2005, 9:00 AM – 9:50 AM, Wyndham/Diamond, Moderator: Bill Goetzler

Seminar 8: Control Challenges and Opportunities with Emerging DDC Technologies
(TC 1.4 sponsor, TC 7.5 co-sponsor)
Sunday, February 6, 2005, 10:15 AM – 12:15 PM, Wyndham/Scotland B, Chair: Barry Bridges

Symposium OR-05-13: Automated Functional Testing: Methodologies and Air-Handling Unit Applications
(TC 7.5 sponsor)
Tuesday, February 8, 2005, 8:00 AM – 10:00 AM, Wyndham/Scotland B, Chair: John House

Seminar 40: Future Intelligent Control Systems: They Are Here Today!
(TC 7.4 sponsor, TC 7.5 co-sponsor)
Tuesday, February 8, 2005, 10:15 AM – 12:15 PM, Wyndham/Ireland C, Chair: Jim Braun

Attached is a draft agenda for the full TC 7.5 committee meeting. I hope to see you all in Orlando.

John House
Chairman, TC 7.5

ASHRAE TC 7.5, Smart Building Systems
2001 2005 Winter Meeting
Orlando, FL

Location: **Wyndham Palace Resort / Scotland A**
Date: **Tuesday, February 8, 2005**
Time: **3:30 - 6:00 p.m.**

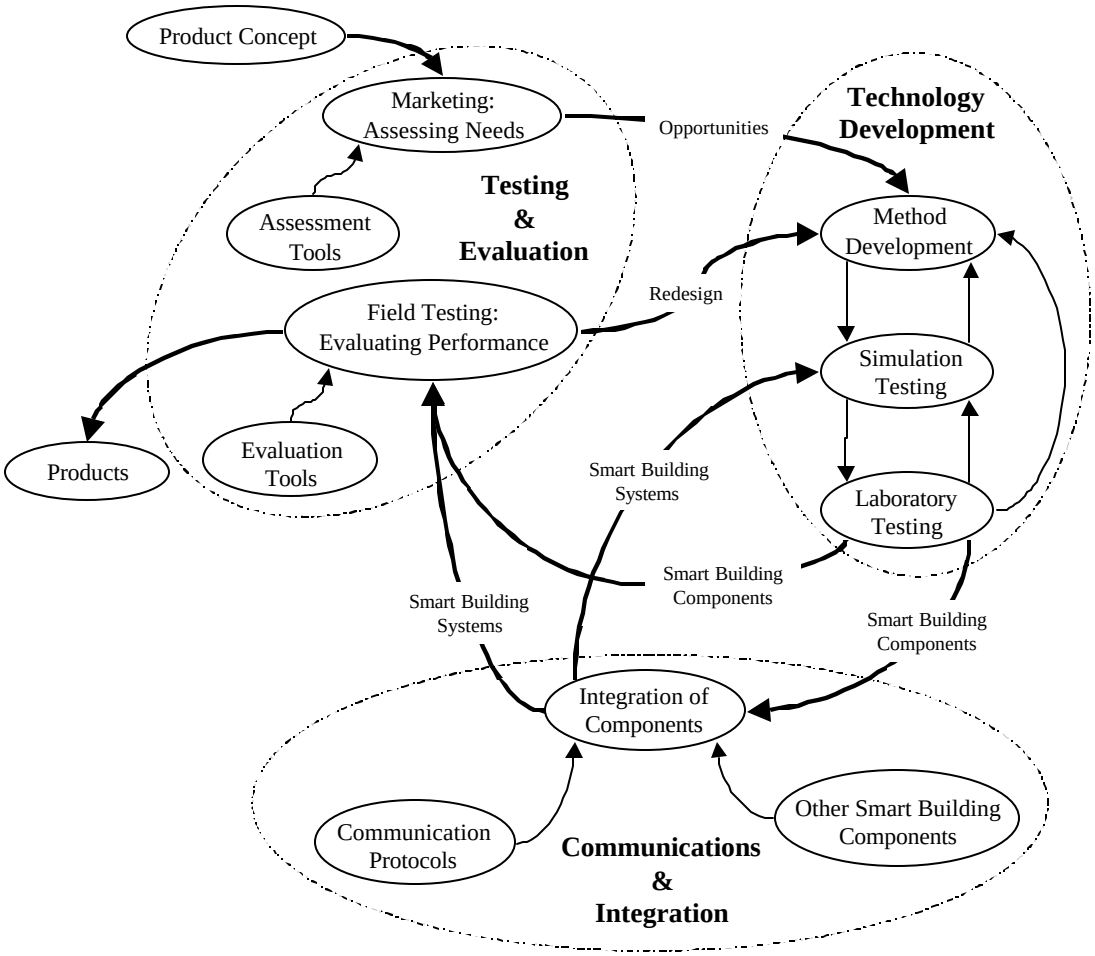
1. Roll call and introductions
2. Approval of minutes from Nashville
3. Announcements
4. Technology Development Subcommittee (Srinivas Katipamula)
    - Report on 1275-RP "Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II" (Phil Haves – PMSC Chair)
5. Communications and Integration Subcommittee (Peng Xu)
6. Testing and Evaluation Subcommittee (Natascha Castro)
    - Report on 1274-RP "Field Performance Assessment of Package Equipment to Quantify the Benefits of Proper Service" (Todd Rossi – PMSC Chair)
7. Research (Mike Brambley)
8. Program Subcommittee (Rich Hackner)
    - Plans for Denver and Chicago
9. Handbook (Les Norford)
10. Web (Natascha Castro)
11. Old business
12. New business
13. Adjournment

Appendix B.
TC 7.5, Smart Building Systems Scope and Organization
Revised July 1, 2001

Overall Committee Scope

The Technical Committee on Smart Building Systems (SBS), TC 4.11, is concerned with the development and evaluation of technologies that could enable the widespread application of smart building systems. "Smart" buildings should take advantage of automation, communications, and data analysis technologies in order to operate in the most cost-effective manner. This implies integration of building services such as HVAC, fire, security, and transportation; the automation of many of the operation and maintenance functions traditionally performed by humans; and the interaction with outside service providers such as utilities, energy providers, and aggregators. Currently, three subcommittees form the backbone of the TC's activities: technology development, communications and integration, and testing and evaluation. The scope and activities of these subcommittees loosely follow the product development process as depicted in following flow chart and as defined in the following sections.

Smart Building System Development Process



Appendix C.
TC 7.5 Technology Development Subcommittee

February 6, 2005, Orlando, FL
Subcommittee Chair: Srinivas Katipamula

Agenda for the subcommittee meeting:

- RP-1275
- Supermarket FDD RTAR
- Sensor Bias
- RTAR on wireless

RP-1275

Katipamula asked Agami Reddy to summarize the status of RP-1275. Agami provided a brief summary and indicated the PMS is yet to meet and the committee will get a more detailed updated at the main committee meeting.

Reddy reported that the project work started in January due to administrative delays from the October award date. Scheduled to finish August 2005 and may require an extension. Srinivas will follow up on schedule. Intent of project was to use tools developed in RP-1043 and to develop at least 4 FDD methods and evaluate against RP-1043. This has been completed. Three data sets developed based on transient chiller model which will be evaluated in the next 3 months. Summary will be made at PMS committee.

Supermarket FDD

A draft RTAR on the topic of supermarket refrigeration was presented by Daniel Choiniere at Nashville. No changes have been made to the RTAR since then. House volunteered to take the lead on revisions. Hung Pham (Copeland-Emerson) indicated he might be able to help identify common faults in refrigeration systems and he might also be able to provide data. distributed RTAR from Nashville meeting and summarized it for the committee. Project is comparable to work on Chillers.

Phase 1
Phase 2

Mike Brandehmuehl and TC 10.7, 10.9 were identified as good ones to bring in. The forum on supermarket refrigeration at the Nashville meeting was discussed. It was suggested that a liaison with supermarket refrigeration manufacturers (e.g., Tyler) would be useful.

Hung Pham-(Copeland) Emerson climate reported that at some level FDD is already in selected supermarkets today (temperature, condenser fouling) using baseline comparisons to verify cost savings. Hung was interested in predictive capabilities of FDD and ways to extend current technologies. He volunteered to help revise RTAR draft.

Southern California Edison and possible co-funding. Copeland good source for technical expertise, EPA for refrigerant leakage and efficiency.

Copeland will share list of frequent faults.

Automated defrost could give good info. UK company (JTL Systems) developed low-cost

sensor for temp pressure and level in receiver. Arthur will share the RTAR and solicit comments

Sensor Bias Topic.
Arthur asked for help on ‘Smart sensor systems for...” Volunteers will be sought offline.

Use of wireless sensors and benefits
Focus of added value for applications. Champion sought.

Appendix D.
TC 7.5 Communications/Integration Subcommittee

February 6, 2005, Orlando, FL
Subcommittee Chair: Peng Xu
Meeting notes: Peng Xu

Peng outlined the topics that will be discussed in the meeting.
Three new ideas from the brainstorming in the last meeting:
1) What if tool, led by Steve Blanc
2) What to do tool. Les Norford "short-term load control in building via HVAC set point adjustment"
3) Different demand limiting strategies for different buildings. Led by Carlos Haiad.

Michael Kintner-Meyer “self configured control system".

Steve Blanc distributed his writing on "what if simulation"
1) Predictive control has been around for a while, but nothing has been done.
2) Basic idea of the tool is a simulation to help building operator determine what if an action is taken.
3) It is a database driven tool based on either simulation or real data.

Agami Reddy: This tool is very similar to an RTAR description in TC4.7. It is a simulation based data map tool. Simulation is based on:
1) What kind of question operator wants to ask.
2) Level of details for the simulation program.

Mike Brambley: What is the difference between NIST virtual cybernetic buildings?

Mike Brandemuehl: Is this something similar to the flight simulator discussed in 7.4?

Steve Blanc: Will consult with people in 7.4 and 4.7 and come up with a better version.

Carlos Haiad talked about his idea of the research on the different limiting strategies:
1) Strategies based on percentage of the shed, instead of the exact power to shed.
2) Development of the hardware that support the communication.
3) He has some written out on one research project he has worked on.
4) For small commercial, the development of the communication thermostat and generic XML protocol to talk with hardware from different vendors.
5) Mandate the communication thermostat in the state.

The current project is funded by Edison and he will report the future works after he finishes the projects.

Les Norford gave a brief introduction of the short time load curtailment tool. If Utility asks for

shedding, what can people in commercial buildings do?
The RTAR submitted it by 7.4, but rejected. Les asked for additional comments.
Steve Blanc: It is some kind of strategy tool. What needs to be implemented in control system? Suggestion and guidance for control company when they design control systems.
Les Norford: It is not an optimization tool, but a short term tool working with utility company.

Les Norford gives the example of the chiller project, which has three phases. Maybe we should do something similar for this project: putting together several projects and ideas but in different phases.

Agami Reddy: Imagine a scenario that an operator maintains a building. What action should he take if asked to shed. He can: 1) look back history, identify sort of idea based on low mass, high mass of the building; 2) use the detailed calibrated model such as in TC 4.7.

Different level of complexity that operator can react to based on different level of the load shed requirement.

Carlos Haiad: Two scenarios: One is emergency; one is for economic reasons. Current ECMS has different level of demand controls.

Les Norford will continue the discussion in 7.4 and come back with a better version.

Michael Kintner-Meyer talked about "self configuration control system" project. Recommendations have been collected. He never got a chance to respond. Mike Brambley will help Michael to collect those recommendations.

Appendix E.
TC 7.5 Testing and Evaluation Subcommittee Meeting

February 6, 2005, Orlando, FL
Subcommittee Chair: Natascha Castro

Natascha noted that there are two main items: 1) WS 1312 and 2) Chiller Phase III.

John House reported that WS 1312 was conditionally accepted by RAC – Tools for Evaluation FDD for AHUs. Waiting for Purdue to finish the dynamic cooling coil model, which is complete but the PMS has not reviewed. PMS meeting is scheduled for Monday. The second condition was to increase the funds.

John House noted that cooling coil model developed by Purdue is slightly faster than real time, which can be limited. John House asked how wise it is to use the model? Purdue has not looked at speeding up the execution. Phil Haves noted that there is another deliverable from Purdue – empirical model.

M. Kintner-Meyer asked what the speed is. How long does it take to simulate entire year? Model is currently running 2.5x real time. John House wants something that can simulate one year data in two to three days of run time. Mike Brambley asked if there is a way to de-scope that part of the WS?

M. Brandemuehl noted that Purdue was trying to be accurate and were not concerned with speed; he added that in the next three months they are going to look at speeding the execution. Steve Blanc noted that we need to add sensitivity analysis to our WS that deal with modeling.

John House wants to look at de-scoping after the PMS reviews the progress. Steve Blanc - why not wait for six months. Mike Brambley's sub-committee should look at whether we need such a sophisticated model? How accurate do we need to be?

PMS meeting on 1194 is tomorrow at 2:15 p.m. – all are welcome. Agami Reddy asked do we need dynamic model? Will steady-state model work? John House noted that we need some dynamic modeling – maybe first order dynamics need to be captured.

Chiller Phase – III

No progress was made. S. Katipamula noted that Todd Rossi has a patent on FDD for vapor compression systems, which appears to cover phase III chiller work.

Mike Brambley suggested we talk to Todd Rossi offline and then make a decision to move forward. S. Katipamula will arrange a conference call with John House, Todd Rossi and S. Katipamula and follow up with ASHRAE.

Appendix F.
TC 7.5 Research Subcommittee Meeting

February 6, 2005, Orlando, FL
Subcommittee Chair: Mike Brambley

Brambley reviewed the agenda and asked for revisions. No revisions were suggested.

Brambley reported on the ASHRAE Strategic Research Plan draft that had been circulated to the technical committees before the Orlando meeting and announced that the cognizant committee was holding sessions in Orlando for attendees to provide feedback on the current draft. He reported that he planned to attend the last session and would forward any comments of the subcommittee in that session. Nine comments were provided by attendees:

1. Emphasis needs to be given that the topics listed are "examples," not an exhaustive list.
2. Many topics are cross cut topical areas, but this is not explained adequately in the document.
3. The climate in California is different that in the eastern U.S. and the example topic list should capture this diversity.
4. There do not appear to be any goals for HVAC, except for refrigeration.
5. The goals are uneven across the themes with respect to the level of detail.
6. Example 1.2.b (Advanced integrated design principles and processes) needs to be elaborated upon.
7. Smart building should be able to respond to extreme temperatures in sequences.
8. Demand responsiveness and relation to electric grid reliability should be more prominent.
9. Concern was expressed with the process used to develop the plan. This document will likely guide other worldwide. As such, it needs to reflect the thoughts and views of the entire membership, not just the "leadership." Keep politics out of the process.

Brambley asked the topical subcommittee chairs to please provide him updates on status for the TC 7.5 Research Plan before the full committee meeting on Tuesday. To save time, the discussion that had taken place earlier in those subcommittee meetings was not reviewed.

Brambley proposed beginning a discussion on two topics related to TC 7.5's future research agenda and organization:

1. Are there any gaps in the research plan that committee members think should be filled and are sufficiently interested to spearhead and effort to start work on? Are there new technical thrusts that we as a committee should engage?
2. In response to the answer to 1, is the current TC organization appropriate. Should we instead organize the topical subcommittees, create new ones, disband any existing ones, or consolidate subcommittees? Or, should we adjust the scope and/or titles of any of the subcommittees?

Discussion ensured for approximately 10 minutes, after which Brambley announced that he would start an effort to discuss these topics by email between this meeting and the next with the objective of developing a recommendation for consideration at the Denver meeting.

The subcommittee meeting was adjourned.

Appendix G.
TC 7.5 Program Notes

February 6, 2005 (revised 2/17/2005), Orlando, FL
Subcommittee Chair: Rich Hackner

Prioritized Program List for 2005 Denver Summer Meeting:

Priority 1: Forum *"What the Utility Wants to Do to Your Building and How You will Benefit"* (Chair: Michael Kintner-Meyer)

Priority 2 Seminar *"Economic Value of FDD ….Who Benefits? ..and How Much?"* (Chair: Phil Haves)
Co-Sponsors: TC 7.4

Priority 3 Forum *"Wireless Sensing and Control…Where Is It Needed and What Should It Control?"* (Chair: Michael Brambley)
Co-Sponsors: TC 1.4? and TC 7.4

History

The TC 7.5 prioritized program for Orlando was:

Priority 1: Forum "What is needed to achieve widespread market acceptance of HVAC Fault Detection and Diagnostic Systems?" (Chair: William Goetzler)
Status: Held Sunday morning: Forum #2

Priority 2: Seminar "In 2010: What Will a Building Have to Say? ..and Who Will Listen?" (Chair: Phil Haves)
Status: Not accepted. Decision to remove this from our list at the Orlando meeting

Priority 3: Forum "What the Utility Wants to Do to Your Building and How You will Benefit" (Chair: Michael Kintner-Meyer)
Status: Not Accepted. Decision to rank 31 and re-submit for Denver

In addition, there were two other programs discussed and ranked:

Priority 4: Seminar "HVAC Demand Response in Short Term Shortage" (Co-chairs Carlos Haiad and Frank Lennorducci)

Priority 5: Seminar "How to use Building Data for Better Operation" (Chair: Mark Johnson)

Program Package Deadlines

Program	Date Tech Papers Due For Review	Completed Packages Due
Denver, CO	September 24, 2004	February 18, 2005
Chicago, IL	April 1, 2005	August 5, 2005
Quebec City, Canada	September 23, 2005	February 10, 2006

Other Ideas for Denver and Beyond

Symposium (Chicago?)
Automated Commissioning…From the Case Files of IEA Annex 40
Lead: John House
Co-sponsors: 7.9?

Seminar Denver
FDD…Fault Detection and Diagnostics…but What about "Correction?"
Lead: Someone from PNNL?
Co-Sponsors: TC 7.4?

Seminar (Chicago?)
Peel and Stick…The Future in HVAC Sensing Technology?
Lead: Michael Brambley
Co-Sponsors: TC 1.4?
Possible Speakers: Mike Schell and Glen Remington

Appendix H.
TC 7.5 Smart Building Systems
1275-RP PMSC Notes

February, 2005, Orlando, FL
Subcommittee Chair: Philip Haves

The aim of the project is to evaluate fault detection and diagnosis (FDD) methods for existing chillers in the field. The contractor is Drexel University, Agami Reddy PI, with Purdue University as a subcontractor. Contractually, the project is due to finish March 29, 2005. Four FDD methods are currently being evaluated. They are all 'data-driven', i.e. empirical, methods; the starting point for each of the methods is the definition of Characteristic Quantities (CQ's), e.g. water temperature difference across the evaporator, and Characteristic Parameters (CP's), e.g. the thermal conductance of the condenser. The basis of each method is to use CQ's and CP's to indicate and, where possible, localize faults. A key part of the development of each method is identifying CQ's and CP's, or combinations thereof, that vary significantly in the presence of faults.

The PMS was given a 120 page report that will evolve into the final report. A considerable amount of work has been done and a preliminary evaluation of the methods produced in terms of the proportion of correct fault detections and diagnoses. There was some discussion about how to treat false positive detections and diagnoses. One suggestion was to set the thresholds for each method so as to produce the same (low) rate of false positives before comparing the rates of correct detections and diagnoses.

A major issue for the project and for the TC is the extent to which the diagnosis rules developed in the project are generic, derived as they are from measurements on the one chiller studied in 1043-RP. Another issue raised was the amount of data required to configure each method, from field tests and/or the manufacturer's performance map. These issues raised the broader issue of to what extent this project will complete the method development and evaluation work required before proceeding to the selection, implementation and field evaluation of a single method in Phase 3.

The actual work on the project was late starting due to contracting delays. A no cost extension will be needed to complete the project.

Appendix I.
List of Subcommittee and Committee Attendees

Orlando, FL – February 2005

	Main Committee	Technology Development	Communications & Integration	Testing & Evaluation	Research
Voting Members					
Osman Ahmed (V)					
Steve Blanc, (V)	X	X	X	X	X
Michael Brandemuehl (V)	X		X	X	X
James Braun (V)	X				
Arthur Dexter, International Member (V)	X	X	X	X	X
Cliff Federspiel (V)	X				
James W. Gartner, CM	X				
Rich Hackner, Program Subc. (V)	X	X	X	X	X
Phil Haves, (V)	X			X	
Bill Healy (V)	X		X	X	X
John House, Chair (V)	X	X	X	X	X
Srinivas Katipamula, Tech. Dev. Subc. Chair (V)	X	X	X	X	X
Agami Reddy (V)	X	X	X	X	X
Jonathan Wright, International Member (V)					
Non-Voting Members					
Eric Adams					
Narendra Amarnani					
Peter Armstrong, CM	X				
Don Aumann					
Kim Barker					
David Bornside	X				X
Mike Brambley, Vice-Chair, Research Chair, CM	X	X	X	X	X
Dave Branson, CM					
Rob Braun		X			
Mark Breuker					
Barry Bridges, CM	X				
Martha Brook		X	X	X	X
Marty Burns,CM					
Jim Butler, CM					
Par Carling					
Natascha Castro, Testing & Eval Subc, Web Master	X	X	X	X	X
Daniel Choiniere					
Christian Christiansen					
Maria Corsi, CM					
Yujie Cui		X			
Charles Culp, CM					
Piotr Domanski	X		X	X	X
Jon Douglas					
Andy Drysdale		X	X	X	X

Chris Early					

	Main Committee	Technology Development	Communications & Integration	Testing & Evaluation	Research
Thomas Engbring, CM					
Mohsen Farzad	X				
Paul Francisco					
Adam Froehlich					
Theo Frutiger					
Brent Griffith					
Peter Gruber					
Carlos Haiad	X	X	X	X	X
David Hansen					
Kirstin Heinemeier					
Gregor Henze	X				X
David Holmberg					
Mark Johnson					
David Kahn, CM	X				
George Kelly, CM	X	X	X	X	X
Richard Kelso					
Michael Kintner-Meyer		X	X	X	X
Hofu Kiu					
Curtis Klaassen	X				
Erin Kruse					
Damian Ljungquist					
Carol Lomonaco, CM,					
Haorong Li					
Mingsheng Liu					
Tor Malmstron					
Rodney Martin					
Darrell Massie	X				
Robert McDowall					
John Mitchell , CM					
Ron Nelson, CM					
Les Norford			X	X	X
Zach Obert					
Robert Old, CM	X	X	X		
Vance Payne	X	X		X	X
Hung Mahn Pham, CM		X	X		
Kinga Porst, CM					
Michael Pouchak					
Andrew Price					
Barry Reardon, CM					
Wayne Reedy					
Paul Reimer					
Glenn Remington, CM	X	X	X	X	X
Todd Rossi, CM, Secretary					
Tim Salsbury					
Jeffrey Schein					

	Main Committee	Technology Development	Communications & Integration	Testing & Evaluation	Research
Chris Scruton					
John Seem, CM					
Virgil Seribo					
David Shipley	X	X		X	X
Vernon Smith	X	X	X	X	X
Pornsak Songkakul, CM					
Gene Strehlow	X				
Changlin Sun					
Steven Szymurski					
Peter Tsilivis					
Keith Temple	X	X	X	X	X
Matthew Tyler, CM					
Hossein Vaezi-Nejad					
Dave Underwood					
Jean Christopher Visier					
Jim Wen					
Jonathan West					
James Winston, CM					
Peng Xu,Comm. & Int. Subc. Chair, CM	X	X	X	X	X
Chariti Young, CM					
Miao Yang					
Jensen Zhang					
Song Zhang					
Xiaohui Zhou					